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ENVIRONMENT

Mr. Keith M. Krawczyk
Project Coordinator
MDEQ-RRD-Superfund
Constitution Hall – 3rd Floor South
525 West Allegan Street
Lansing, Michigan 48909-7926

Subject:
Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
King Highway Landfill Operable Unit 3
Stressed Vegetation Sampling Results and Work Plan

Date:
June 27, 2012

Contact:
Patrick McGuire

Phone:
315.671.9233

Email:
pat.mcguire@arcadis-us.com

Our ref:
B0064583.0003.00907
#10

Dear Mr. Krawczyk:

On behalf of Georgia-Pacific LLC (Georgia-Pacific), this document has been prepared to address the sample results from the observed stressed vegetation at the King Highway Landfill Operable Unit 3 (KHL OU) of the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Site). This document is organized as follows:

1. Background information related to the stressed vegetation;
2. Summary of recent sampling activities;
3. Field investigation findings;
4. Proposed corrective measures; and
5. Schedule.

These items are further discussed below:

1. BACKGROUND INFORMATION RELATED TO THE STRESSED VEGETATION

On February 27, 2012, the Michigan Department of Environmental Quality (MDEQ) informed Georgia-Pacific of an area with stressed vegetation (SV-A) located on the north side of the KHL (Figure 1) (MDEQ 2012). On March 8, 2012, representatives from MDEQ, Georgia-Pacific, and ARCADIS participated in a conference call to discuss the next steps for investigating the cause of the stressed vegetation. During the call, Georgia-Pacific agreed to develop a sampling plan to evaluate the source of the stressed vegetation identified on the final cover system.

The Sampling Plan for the Stressed Vegetation Area (Stressed Vegetation Area Sampling Plan; ARCADIS 2012a) was submitted to MDEQ on April 27, 2012 for review. While the plan was not formally approved by MDEQ, notification was provided to MDEQ on May 15, 2012 of Georgia-Pacific's intention to implement the sampling plan activities in conjunction with upcoming annual groundwater and quarterly landfill gas monitoring activities (ARCADIS 2012b).

2. SUMMARY OF FIELD INVESTIGATION ACTIVITIES

On May 31, 2012, ARCADIS met with CDM Smith (MDEQ's on-site representative) at the KHL to conduct soil gas sampling of stressed vegetation area SV-A in accordance with the Stressed Vegetation Area Sampling Plan. A ¾-inch diameter temporary borehole (BH-1) was installed by ARCADIS in stressed vegetation area SV-A to an approximate depth of 1 foot below ground surface (bgs) using a slide hammer (see Figure 1). A GEM-500™ portable gas analyzer was used to monitor the soil gas characteristics within the borehole, which included methane (CH_4), carbon dioxide (CO_2), oxygen (O_2), and balance nitrogen (N).

Monitoring of the initial borehole BH-1 resulted in a detection of methane above the lower explosive limit (LEL). At the direction of CDM Smith, three additional temporary boreholes BH-2, BH-3, and BH-4 were installed by ARCADIS approximately 30 feet southeast, 80 feet south, and 130 southeast of stressed vegetation area SV-A, respectively (see Figure 1). The additional temporary boreholes were installed to an approximate depth of 1 foot bgs using a slide hammer. The soil gas sampling conducted within temporary boreholes BH-2, BH-3, and BH-4 resulted in no detections of methane. The results of the soil gas sampling are shown in Table 1 below.

Table 1. Soil Gas Sampling Results

Temporary Borehole ID	Location	CH_4 (%)	CO_2 (%)	O_2 (%)	Balance N (%)
BH-1	stressed vegetation area	23.3	19.5	9.0	48.3
BH-2	30 feet SE of stressed vegetation area	0.0	0.1	20.5	79.4
BH-3	80 feet S of stressed vegetation area	0.0	0.1	20.5	79.4
BH-4	130 feet SE of stressed vegetation area	0.0	0.1	20.5	79.4

Notes:
1. CH_4 – Methane
2. CO_2 – Carbon dioxide
3. O_2 – Oxygen
4. N – Nitrogen

During the May 31, 2012 soil gas sampling activities, areas of stressed vegetation other than stressed vegetation area SV-A were observed on the final cover. As a follow-up, on June 7, 2012, ARCADIS traversed the KHL in 50-foot by 50-foot grid increments to visually inspect the surface of the final cover for other areas of stressed vegetation. In all other areas of stressed vegetation identified during the inspection (i.e., SV-B through SV-G), a ¾-inch diameter temporary borehole was installed by ARCADIS to an approximate depth of 1 foot bgs and soil gas was sampled for CH_4, CO_2, O_2, and balance N concentrations. The soil gas sampling conducted within additional stressed vegetation areas SV-B through SV-E and SV-G resulted in no detections of methane. Within stressed vegetation area SV-F, methane was detected at a concentration above the LEL. However, this area of stressed vegetation (SV-F) is located outside the final cover system. Refer to Figure 1 for the approximate locations of these other areas of stressed vegetation observed at the KHL.

It should be noted that stressed vegetation area SV-D is associated with a drainage channel that has settled and water ponding has been observed. This area will be backfilled with topsoil and regraded to prevent future water ponding.

3. FIELD INVESTIGATION FINDINGS

Based on the results of the soil gas sampling conducted within stressed vegetation area SV-A, it is felt that the source of the gas may be the result of a breach of the final cover system geomembrane liner (i.e., possibly a tear in a seam). The geomembrane panel liner layout drawing (included in Attachment A to this work plan) identifies numerous liner seam repairs (including those associated with patches) completed during installation of the geomembrane liner. The geomembrane panel liner layout drawing also identifies liner seam repairs located in the vicinity of stressed vegetation area SV-A. One of these seams may have failed, causing landfill gas to permeate through the final cover soils and into the ambient air. During inspection of the exposed geomembrane liner below the stressed vegetation, as discussed further in Section 4, attempts will be made to locate any seams in area SV-A to determine whether there is a failure.

4. PROPOSED CORRECTIVE MEASURES

To investigate the possibility of a breach in the final cover geomembrane, Georgia-Pacific will authorize its contactor (Terra Contracting, LLC) to mobilize to the site to remove a portion of the final cover soils, perform an inspection of the existing 40 mil liner low density polyethylene (LLDPE) geomembrane liner, and, if necessary, repair any observed breaches.

The contractor will start by removing the vegetative topsoil and drainage/barrier protection materials from within stressed vegetation area SV-A until the geomembrane liner is exposed. Refer to Figure 2 for a cross-section of the final cover system. Excavation of the cover soils will be observed throughout removal activities to ensure that excavation will be conducted in a manner that would not damage the geomembrane liner. The excavated soil material will be placed immediately adjacent to the excavation area, and segregated into piles based on the soil type and layer from which the material was removed (i.e., drainage/barrier protection layer, vegetative layer; see Figure 2).

Following removal of the soil cover material, the surface of the exposed geomembrane liner will be thoroughly cleaned by hosing off all soil particles with water and brushing the surface with a broom. Once cleaned, the contractor will visually inspect for defects or failures in the exposed geomembrane liner (including failures along any seams) and/or any bubbling water that occurred as a result of hosing off the surface of the geomembrane liner. Once the geomembrane liner is thoroughly cleaned, it will be tested for possible breaches in the liner by vacuum box testing the geomembrane surface (i.e., seams and non-seam surfaces). If no breaches are identified during vacuum box testing, the excavated area will be backfilled and restored as described below and in Attachment B. If a breach is identified, all liner repair and testing activities will be performed by a qualified geosynthetics installation company that will be subcontracted by Terra Contracting, LLC.

Breaches identified in the exposed geomembrane liner will be repaired by installing patches composed of 40 mil LLDPE geomembrane over the liner breach. The geomembrane patch material used for the repair activities at the KHL OU will come from the Willow Boulevard/A-Site OU (WB/A-Site OU), since the material at the WB/A-Site OU has already been quality assurance/quality control tested. The geomembrane patches will be sized to provide a minimum coverage of 12 inches beyond the outer-most edge(s) of the breach and will be extrusion welded to the existing geomembrane liner to create a water-tight seal. The welded patch seams will be vacuum box tested to verify that the welds are sufficient to resist leakage. All repair work, including preparations, patching, and testing of the geomembrane welds, will be conducted in accordance with the Linear Low Density Polyethylene Geomembrane Specification included in Attachment B.

Upon completion of the repair activities, the excavated cover soils will be placed back over the repaired geomembrane liner in the same layer configuration from which the soils were removed (see Figure 2). If necessary, imported general fill and vegetative soil may be used to amend the existing thicknesses of the drainage/barrier protection and vegetative layers, respectively, to achieve the minimum soil thicknesses

identified in the Fill Materials Specification included in Attachment B. Imported vegetative soil will also be placed in stressed vegetation areas SV-B through SV-G, and the area seeded and mulched as specified below, to facilitate vegetative growth within these areas. Imported general fill and vegetative soil material will meet the qualifications described in the Fill Materials Specification (Attachment B). If possible, the general fill and vegetative soil material may be obtained from the WB/A-Site OU cover construction project, since this material has been previously sampled to meet project requirements.

Seed, mulch, and fertilizer will then be applied to the newly graded areas to establish vegetative growth and reduce the potential for erosion. The application of seed, mulch, and fertilizer to restored areas is described further in the Restoration Plantings Specification; and the requirements and application rates are identified in the Vegetative Soil, Seeding, and Mulch Specification, which are included in Attachment B.

Based on the proposed use of materials from the WB/A-Site OU cover construction project, the specifications included in Attachment B were taken directly from the WB/A-Site OU cover construction project. It is noted that only certain components of these specifications are applicable to the KHL OU.

In addition, during the next quarterly landfill gas monitoring event (anticipated to be conducted in August 2012), the area of repaired geomembrane liner will be tested for methane concentrations to evaluate the effectiveness of the repairs. This testing will be performed consistent with the Stressed Vegetation Area Sampling Plan.

5. SCHEDULE

Georgia-Pacific plans to mobilize to the KHL within 30 days following receipt of MDEQ approval of this work plan. It should be noted that mobilization to the site is contingent upon delivery of geomembrane liner material to the WB/A-Site OU. Georgia-Pacific will provide MDEQ with a minimum of 10 days notification prior to mobilization to the site. Upon mobilization, it is anticipated that the work described above can be completed in approximately one to two weeks, barring any unexpected conditions or delays.

A summary report documenting the completion of the geomembrane liner repair activities within stressed vegetation area SV-A, and regrading and reseeding of stressed vegetation areas SV-B through SV-G will be developed and submitted to MDEQ within 60 days following completion of the aforementioned activities.

If you have any questions, please do not hesitate to contact me.

Sincerely,

ARCADIS

Patrick McGuire
Principal Environmental Engineer

Copies:
Daria Devantier, MDEQ
Judith Alfano, MDEQ
Michael Berkoff, USEPA Region 5
Garry Griffith, P.E., Georgia-Pacific
Dawn Penniman, P.E., ARCADIS

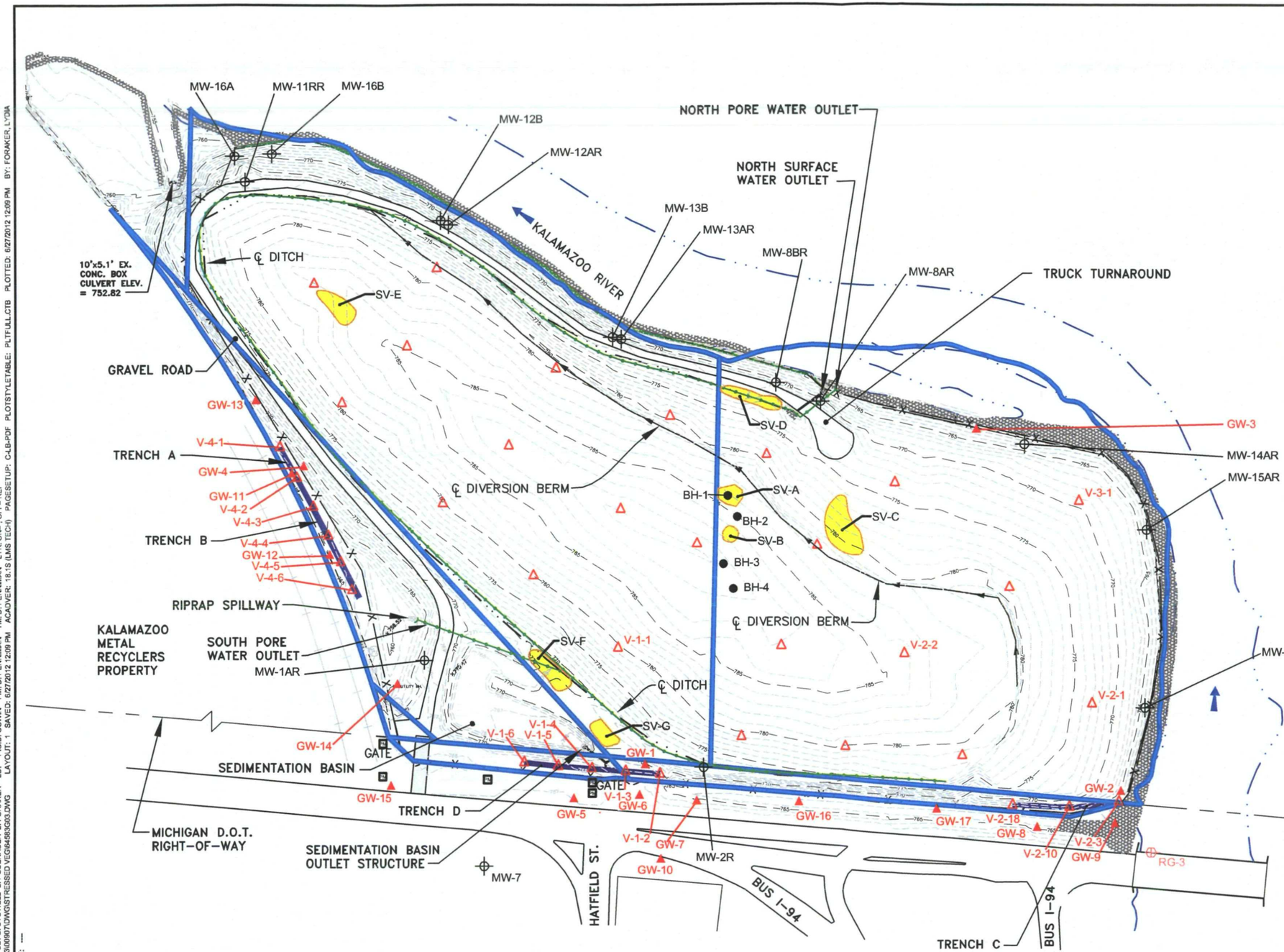
Attachments:
Figure 1 – Stressed Vegetation and Soil Gas Monitoring Locations
Figure 2 – Final Cover System Cross-Section Detail
Attachment A – Geomembrane Panel Liner Layout
Attachment B – Specifications

References:

ARCADIS 2012a. Sampling Plan for the Stressed Vegetation Area. April 27, 2012.

ARCADIS 2012b. E-mail from ARCADIS to MDEQ Regarding Water Level Measurement Collection and Schedule. May 15, 2012.

MDEQ 2012. E-mail from MDEQ to Georgia-Pacific Regarding Area of Stressed Vegetation and Pore Water Discharge. February 27, 2012.



LEGEND:

- APPROXIMATE PROPERTY BOUNDARY
- DITCH LINE
- ABANDONED RAILROAD
- SHEETPILE WALL
- ACCESS ROAD
- RIPRAP
- CULVERT PIPE
- FINAL AS-BUILT INDEX CONTOUR
- FINAL AS-BUILT INTERMEDIATE CONTOUR
- SECURITY FENCE
- PORE WATER COLLECTION PIPE
- PORE WATER DRAIN
- APPROXIMATE WATER EDGE
- GAS VENTS (ORIGINAL 23; ONLY FOUR WERE GIVEN IDs)
- V-1-2 CUTOFF TRENCH GAS VENTS
- LANDFILL GAS CUTOFF TRENCH
- FLOW DIRECTION
- MW-14 MONITORING WELL
- RG-3 RIVER GAUGE STATION
- GW-2 LOCATION OF GAS MONITORING PROBES
- BH-2 TEMPORARY BOREHOLE LOCATION
- SV-A APPROXIMATE LOCATION OF STRESSED VEGETATION AREA AND ID

NOTES:

1. BASE MAP INFORMATION OBTAINED FROM CADD DRAWING FILE DEVELOPED BY RMT, INC., ANN ARBOR, MICHIGAN (CADD FILE: L1630SU01.DWG AS-BUILT SURVEY; 8/21/00).
2. FINAL AS-BUILT CONTOUR ELEVATIONS ARE SHOWN AND ARE BASED ON A FIELD SURVEY BY ATWELL-HICKS, INC., DATED 9/27/00 WITH REVISIONS DATED 10/23/00, 12/21/01, 12/10/02, AND 7/24/03.
3. FINAL AS-BUILT CONTOUR ELEVATIONS OF SEDIMENTATION BASIN ARE BASED ON A FIELD SURVEY BY PREIN & NEWHOF, DATED 2/3/04.
4. PROPERTY BOUNDARY, AND FINAL AS-BUILT CONTOUR ELEVATIONS OF PARCEL C AND SURROUNDING AREAS BASED ON A FIELD SURVEY BY PREIN & NEWHOF, DATED 11/19/2010.
5. ELEVATIONS ARE BASED ON NGVD OF 1929 (MSL).
6. PROPERTY SURVEY PERFORMED BY WILKINS & WHEATON ENGINEERING CO., INC., ON 7/1/96.
7. TOPOGRAPHIC CONTOUR INTERVAL IS 1 FOOT.
8. LOCATIONS OF GW-5, GW-6, GW-7, GW-8, GW-9, AND GW-10 ARE BASED ON A FIELD SURVEY BY TERRA CONTRACTING LLC, DATED 9/23/05.
9. LOCATION OF GW-11 IS BASED ON A FIELD SURVEY BY TERRA CONTRACTING LLC, DATED 1/11/06.
10. LOCATIONS OF RG-6, V-4-4, V-4-5, AND V-4-6 ARE BASED ON A FIELD SURVEY BY TERRA CONTRACTING LLC, DATED 6/7/06.
11. LOCATIONS OF V-1-2 THROUGH V-1-6, V-2-3, V-2-10, AND V-2-18 ARE BASED ON MULTIPLE FIELD SURVEYS CONDUCTED BY TERRA CONTRACTING LLC. IN APRIL 2008. GAS VENTS V-2-4 THROUGH V-2-9, AND V-2-11 THROUGH V-2-17 ARE NOT SHOWN FOR CLARITY PURPOSES (THESE VENTS ARE LOCATED ALONG TRENCH C).
12. LOCATION OF GW-12 IS APPROXIMATE.
13. LOCATIONS OF GW-13 THROUGH GW-17 BASED ON FIELD SURVEY CONDUCTED BY PREIN & NEWHOF ON 11/1/11.
14. LOCATION OF SHEETPILE WALL AND A PORTION OF THE MONITORING WELLS ARE BASED ON A FIELD SURVEY BY ATWELL-HICKS, INC. DATED 9/27/00.
15. PARCELS 1, 2, 10, A, B, AND THE TRIANGLE PARCEL ARE OWNED BY GEORGIA-PACIFIC.
16. GEORGIA-PACIFIC PURCHASED THE "TRIANGLE PARCEL" FROM THE MICHIGAN DEPARTMENT OF TRANSPORTATION (MDOT) IN EARLY 2006.
17. GEORGIA-PACIFIC PURCHASED PARCELS A (PREVIOUSLY OWNED BY MDOT) AND B (PREVIOUSLY OWNED BY THE CITY OF KALAMAZOO) IN JUNE 2008, WHICH ARE LOCATED IN THE PORTION OF THE KING HIGHWAY (M-96) RIGHT-OF-WAY THAT IS ENCLOSED BY THE KING HIGHWAY LANDFILL SITE BOUNDARY FENCE.

ALLIED PAPER, INC./PORTAGE CREEK/
KALAMAZOO RIVER SUPERFUND SITE

STRESSED VEGETATION SAMPLING RESULTS AND WORK PLAN

STRESSED VEGETATION AND SOIL GAS MONITORING LOCATIONS

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FIGURE 1

CITY: SYRACUSE DIV/GROUP: ENVCAD DB: G. STOWELL L: POSENAUER, L: FORAKER LD: PIC: D. COWN PM: D. PENNIMAN TM: D. PENNIMAN LYR: ON=*; OFF=*REF*
G:\ENVCAD\SYRACUSE\ACTIVE\64583000\699\TOXGISTRESSED VEG\64583093.DWG LAYOUT: 1 SAVED: 8/27/2012 12:09 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: C:\LB-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 6/27/2012 12:09 PM BY: FORAKER, LYDIA
XREFS: 64583X11
64583X00
IMAGES:
PROJECTNAME: ---

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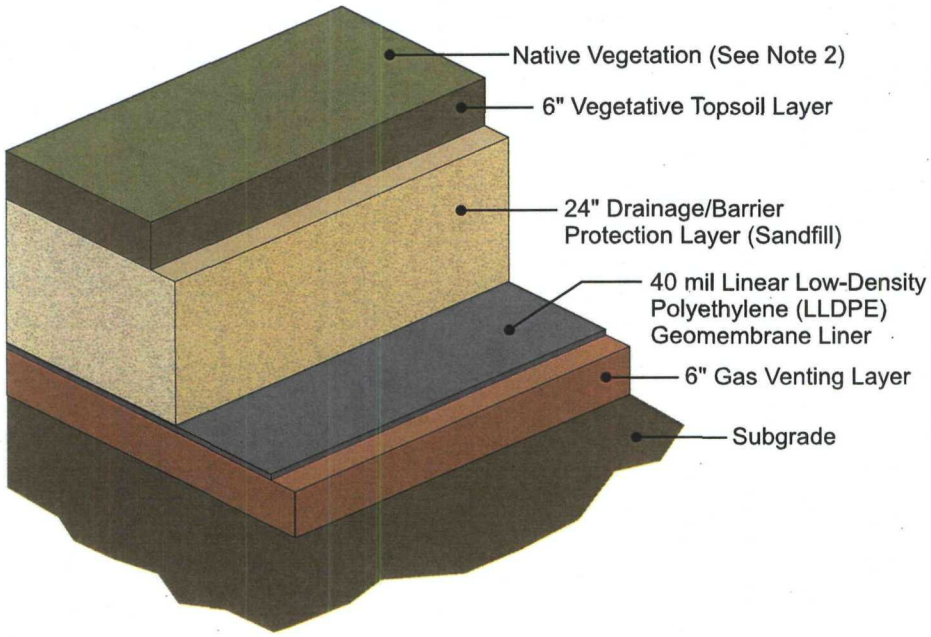
Figure 2

Final Cover System Cross-Section Detail



FINAL COVER SYSTEM DETAIL

NOT TO SCALE

NOTES:

1. The barrier protection and gas venting layers consists of imported, permeable, clean soil.

2. Native Vegetation consists of Tall Fescue, Creeping Red Fescue, Kentucky Bluegrass, Perennial Ryegrass, and Annual Ryegrass.

ALLIED PAPER, INC./PORTAGE CREEK/
KALAMAZOO RIVER SUPERFUND SITE

STRESSED VEGETATION SAMPLING RESULTS AND WORK PLAN

FINAL COVER SYSTEM CROSS-SECTION DETAIL

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FIGURE
2

06/27/2012 SYRACUSE, NY-ENV/CAD DJHOWES
B0064583/0003/00907/CDR/64583G03.CDR

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Attachment A

Geomembrane Panel Liner Layout

DRAWN BY: S.G. DATE: 12-22-99				
CHECKED BY: DATE:				
SCALE: 1"= 50'	1	AS-BUILT	12-22-99	S.G.
GSI JOB #:99051	NO.	REVISIONS	DATE	BY

GSI
GEO-SYNTHETICS, INC.
428 N. PEWAUKEE ROAD
WAUKESHA, WI 53188
414-524-7979

AS-BUILT
FOR
KING HIGHWAY LANDFILL
OPERABLE UNIT CLOSURE
CONSTRUCTION (CELLS 1,2,3,AND 4)

KING HIGHWAY LANDFILL
OPERABLE UNIT CLOSURE
CONSTRUCTION (CELLS 1,2,3,AND 4)
KALAMAZOO, MI

GEOMEMBRANE MATERIAL
40 MIL LLDPE

FILENAME	KING HWY
DRAWING #	L990172

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Attachment B

Specifications

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Attachment B – Specifications
Table of Contents

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
King Highway Landfill Operable Unit 3

Linear Low Density Polyethylene Geomembrane

Fill Materials

Restoration Plantings

Vegetative Soils, Seeding, and, Mulch

(Based on the proposed use of materials from the WB/A-Site OU cover construction project, the specifications included herein were taken directly from the WB/A-Site OU cover construction project. It is noted that only certain components of these specifications are applicable to the KHL OU)

Linear Low Density Polyethylene
Geomembrane

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ATTACHMENT B

LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE

PART 1. GENERAL

1.1 SCOPE OF WORK

A. The Geosynthetics Installer shall furnish all labor, materials, tools, supervision, transportation and installation equipment necessary for the installation of the geomembrane as specified in the Project Documents. The Geosynthetics Installer shall be under direct contract to the Contractor.

B. The Geosynthetics Installer shall be prepared to install the geomembrane in conjunction with earthworks and other components of the final cover system.

C. The Geosynthetics Installer will install the geomembrane and provide testing services for all installed geomembrane.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D792 Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement

2. D1004 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting

3. D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer

4. D1248 Standard Test Method for Polyethylene Plastics Molding and Extrusion Materials

5. D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique

6. D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

7. D4437 Standard Test Method for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes

8. D4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

9. D5199 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

10. D5397 Standard Test Method for Single-Point Notched Constant Load Test

11. D5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

12. D5994 Standard Test Method for Measuring the Core Thickness of textured Geomembranes

13. D6392 Standard Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

14. D6693 Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

B. Geosynthetic Research Institute (GRI):

1. GM 6 Standard Practice for Pressurized Air Channel Test for Dual Seamed Geomembranes

2. GM 12 Asperity Measurement of Textured Geomembranes Using a Depth Gage

3. GM 17 Test Methods, Test properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

4. GM 19 Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.3 QUALITY ASSURANCE

A. Quality Assurance Program: The Contractor and the Geosynthetics Installer shall agree to participate in and conform to all items and requirements of the quality assurance program as outlined in this Specification, and in the Project Documents.

ATTACHMENT B

LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE

1.4 QUALIFICATIONS

A. Contractor:

1. The Geosynthetics Installer will be contracted directly by the Contractor. The Geosynthetics Installer shall meet the qualification requirements of this Specification.

B. Geomembrane Manufacturer:

1. The Geomembrane Manufacturer shall be responsible for the production of geomembrane rolls from resin and shall have sufficient production capacity and qualified personnel to meet the demands (e.g., quantity production, and quality control) of this project.

2. The Geomembrane Manufacturer shall have at least 5 years of continuous experience in manufacturing LLDPE geomembrane and have produced 10,000,000 square feet (minimum) of LLDPE geomembrane and installed at least 8,000,000 square feet.

C. Geosynthetics Installer:

1. The installer of the geomembrane shall be the Geosynthetics Installer who shall be responsible for field handling, storing, deploying, seaming, temporarily restraining (against wind), and other site aspects of the LLDPE geomembrane and other components of the final cover system.

2. The Geosynthetics Installer shall have at least 5 years of continuous experience in installing polyethylene geomembrane and have installed 5,000,000 square feet (minimum) of polyethylene geomembrane for at least 10 completed facilities.

3. Personnel performing seeming operations shall be qualified by experience or by successfully passing seaming tests. At least one seamer shall have experience in seaming 1,000,000 square feet (minimum) of polyethylene geomembrane using the same type of seaming apparatus to be used on this project. The most experience seamer, called the "master seamer," shall provide direct supervision, as required, over less experienced seamers.

4. The laboratory used by the Geosynthetics Installer for laboratory testing of destructive seam samples shall have extensive experience with all types of geosynthetics and be accredited members of the Geosynthetics Accreditation Institute – Laboratory Accreditation Program (GAI-LAP).

D. Conformance Testing and Interface Friction/Direct Shear Testing Laboratory

1. An independent laboratory contracted directly by the Owner, shall be used for conformance testing and interface friction/direct shear testing as required by this Specification. The Conformance Testing Laboratory shall have extensive experience with all types of geosynthetics and be accredited members of the GAI-LAP.

1.5 SUBMITTALS

A. The following items shall be submitted no later than 30 days prior to the start of geomembrane installation or 15 days prior to delivery of the first geomembrane shipment, whichever is earliest.

1. The Geomembrane Manufacturer shall submit the following information in writing to the Owner and the Owner's Representative:

a. Corporate background and information.

b. Manufacturing Quality Control (MQC) Plan.

c. Manufacturing capabilities, including:

1) Information on plant size, equipment, personnel, number of shifts per day, and capacity per shift;

2) Daily production quantity available for this Contract;

3) Manufacturing quality control procedures; and

4) List of material properties, including certified test results, attached to which is a geomembrane sample.

ATTACHMENT B

LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE

d. A list of at least ten completed facilities for which the Geomembrane Manufacturer has manufactured a minimum of 10,000,000 square feet of polyethylene geomembrane. The following information shall be provided for each facility:

   1) Name, location, and purpose of facility, and date of installation;

   2) Names of Owner, Project Manager, Engineer, General Contractor, fabricator (if any), and installer; and

   3) Type, thickness and quantity of geomembrane manufactured.

e. Origin (resin supplier's name, resin production plant) and identification (brand name, number) of the polyethylene resin.

f. Copies of quality control certificates issued by the resin supplier.

g. Results of tests conducted by the Geomembrane Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.

h. Certification that no reclaimed polymer is added to the resin during the manufacture of the geomembrane to be used for this project. The use of polymer recycled during the manufacturing process may be permitted if performed with appropriate cleanliness and if the recycled polymer does not exceed 10% by weight of the total polymer weight.

i. Manufacturing certificates for each shift's production of geomembrane, signed by responsible parties employed by the Geomembrane Manufacturer (such as the production manager), and notarized.

j. Quality control certificates providing the results of the quality control tests outlined in Section 2.3(A) of this Specification.

   1) The quality control certificates shall include:

      a) Roll numbers and identification;

      b) Sampling procedures; and

c) Results of quality control tests, including descriptions of the test methods used.

2. The Geosynthetics Installer shall submit the following information in writing to the Owner and the Owner's Representative:

a. Corporate background and information.

b. Copy of installer's letter of approval or license by the Geomembrane Manufacturer and/or fabricator.

c. Construction Quality Control (CQC) Plan.

d. Installation capabilities, including:

1) Information on equipment and personnel;

2) Average daily production anticipated for this project;

3) Quality control procedures; and

4) Samples of field seams, a certified list of minimum values for seam properties, and the test methods employed.

e. A list of at least 10 completed facilities, for which the installer has installed a minimum of 5,000,000 square feet of polyethylene geomembrane. The following information shall be provided for each facility:

1) The name and purpose of the facility, its location, and dates of installation;

2) The names of the Owner, Project Manager, Engineer, General Contractor, Geomembrane Manufacturer, fabricator (if any), and the name of a contact at the facility who can discuss the project;

3) Name and qualifications of the installer's supervisor(s);

4) Thickness and surface area of installed geomembrane;

5) Type of seaming and type of seaming apparatus used; and

6) Duration of installation.

f. Resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment.

g. Resume of the installation supervisor to be assigned to this project, including dates and duration of employment. The superintendent shall have supervised the installation of a minimum of 2,000,000 square feet of polyethylene geomembrane.

h. Proposed installation panel layout drawing showing the placement of geomembrane panels, seams and any variances or additional details which deviate from the Construction Drawings.

i. Installation schedule.

j. The name and qualifications of the proposed laboratory that will be responsible for laboratory testing of destructive seam samples.

3. The Contractor shall submit the following information in writing to the Owner and the Owner's Representative:

a. Certification that the field-delivered geomembrane has not been damaged due to improper transportation, handling, or storage.

b. Certification that the surface on which the geomembrane is to be installed is acceptable to both the Engineer and the Contractor. The certification is subject to the review and approval or rejection by the Owner.

B. During installation, the Geosynthetics Installer shall submit the following information to the Owner and the Owner's Representative:

1. Subgrade acceptance certificates signed by the installer for each area to be covered by the geomembrane;

2. Daily field logs documenting the work being performed, personnel involved, general working conditions, and any problems encountered or anticipated on the project;

3. Field quality control documentation (i.e., trial seam tests, destructive tests, non-destructive tests, etc.); and

4. A Certificate of Calibration less than 12 months old for the field tensiometer referenced in Section 3.3(H)(2) of this Specification.

C. Upon completion of the installation, the Geosynthetics Installer shall be responsible for the timely submission of the following:

1. Geomembrane installation certification;

2. As-built panel layout diagram; and

3. Warranty from Geomembrane Manufacturer/Installer as specified in Section 1.6 of this Specification.

1.6 WARRANTY

The Geomembrane Manufacturer and Geosynthetics Installer shall furnish a standard written warranty against defects in material and workmanship. Warranty duration and conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.

PART 2. PRODUCTS

2.1 MANUFACTURERS

A. LLDPE Geomembrane

GSE Lining Technology Inc.	Poly-Flex, Inc.
19103 Gundle Road	2000 West Marshall Drive
Houston, TX 77073	Grand Prairie, TX 75051
1.800.435.2008	1.888.765.9359

B. An alternate Geomembrane Manufacturer may be considered. The Contractor shall submit the alternate material to the Engineer for review.

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2.2 MATERIALS

A. Polyethylene Geomembrane Resin

1. The resin shall comply with the following LLDPE specified properties:

   a. Specific Gravity: 0.926 g/ml, maximum (ASTM D792 Method B, or ASTM D1505); and

   b. Melt Index: 1.0 g/10 minute, maximum (ASTM D1238 Condition E 190 °C, 2.16 kg).

2. Resin shall be virgin material with no more than 10% rework (by weight). Rework material shall be of the same formulation as parent material. No post-consumer resin shall be added to the formulation.

B. LLDPE Geomembrane

1. The LLDPE geomembrane shall meet the required property values shown below and in Table 1 of this Specification.

2. In addition to the property values listed in Table 1 of this Specification, the geomembrane shall:

   a. Contain a maximum of 1% (by weight) of additives, fillers, or extenders (not including carbon black);

   b. Be free of striations, pinholes, or bubbles on the surface or in the interior;

   c. Be produced so as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter; and

   d. Be manufactured in a single layer (thinner layers shall not be welded together to produce the final required thickness) and have a uniform textured appearance on both sides.

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C. Welding Material

1. The resin used in the welding material shall be identical to the liner material.

2. All welding materials shall be of a type recommended and supplied by the Geomembrane Manufacturer and shall be delivered in the original sealed containers, each with an indelible label bearing the brand name, Geomembrane Manufacturer's mark number, and complete directions as to proper storage.

D. Fabrication

1. The geomembrane shall be delivered to the site in rolls or as factory panels. A factory panel is comprised of one or more rolls that have been seamed together in a factory.

2. Labels on each geomembrane roll shall identify the following information:

   a. Name of Geomembrane Manufacturer;

   b. Product identification;

   c. Roll number and dimensions;

   d. Batch number;

   e. Thickness of the material; and

   f. Directions to unroll the material.

2.3 GEOMEMBRANE TESTING REQUIREMENTS

A. Geomembrane Manufacturer's Quality Control Testing

1. Polyethylene Geomembrane Resin

   a. The Geomembrane Manufacturer shall sample and test the resin to demonstrate that the resin complies with this Specification. The Geomembrane Manufacturer shall certify in writing that the resin meets this Specification, and shall be held liable for any non-compliance.

b. Geomembrane material manufactured from non-complying resin will be rejected. Replacement of any rejected geomembrane material will be at no cost to the Owner.

2. LLDPE Geomembrane

a. The Geomembrane Manufacturer shall continuously monitor the geomembrane during the manufacturing process for inclusions, bubbles, or other defects. No geomembrane that exhibits any defects will be accepted.

b. The Geomembrane Manufacturer shall continuously monitor the geomembrane thickness during the manufacturing process. No geomembrane that fails to meet the specified minimum thickness will be accepted.

c. The Geomembrane Manufacturer shall sample and test the geomembrane, in accordance with the MQC Plan to demonstrate that its properties conform to the values specified in Table 1 of this Specification.

1) Samples shall be taken across the entire width of the roll.

2) At a minimum, the following manufacturing quality control tests shall be performed.

Test	Procedure
Thickness	ASTM D5994
Density	ASTM D1505/ASTM D 792
2% Modulus	D 5323
Break Strength	ASTM D6693 Type IV
Break Elongation	ASTM D6693
Tear Resistance	ASTM D1004
Puncture Resistance	ASTM D4833
Carbon Black Content	ASTM D1603
Carbon Black Dispersion	ASTM D5596
Axi-Symmetric Break Resistance Strain	ASTM D5617
Asperity Height	ASTM D7466
Oxidative Induction Time (OIT)	ASTM D3895/ASTM D5885
Oven Aging at 85°C	ASTM D5721/ASTM D3895/ASTM D5885
UV Resistance	ASTM D5885

d. Any geomembrane sample that does not comply with this Specification will be rejected by the Owner.

e. If a roll of geomembrane is rejected, the Geomembrane Manufacturer shall sample and test each roll manufactured in the same batch or at the same time as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.

f. The Contractor shall replace any rejected rolls at no additional cost to the Owner.

g. Additional testing may be performed at the Geomembrane Manufacturer's discretion and expense, to more closely identify the non-complying rolls and/or to qualify individual rolls.

3. The Geomembrane Manufacturer's test results shall be submitted by the Contractor to the Engineer for review, prior to shipping any rolls of geomembrane.

B. Conformance Testing

1. Prior to installation, samples of delivered geomembrane shall be taken and shipped to a third party testing laboratory (i.e. the Owner's Conformance Testing Laboratory), for conformance testing independent of the manufacturer's testing. Unless otherwise specified, the samples shall be taken at a minimum frequency of one sample per 100,000 square feet with a minimum of one sample per lot of material delivered to the site (regardless of the dates of manufacturing or delivery dates). At least one sample shall also be obtained from geomembrane rolls representing each resin production batch.

2. Samples shall be at least 3 feet long by the roll width and shall not include the first 3 feet of any roll.

3. Conformance testing shall be the responsibility of the Owner.

4. The Contractor shall, at no additional cost to the Owner, provide whatever reasonable assistance the Engineer may require in obtaining the samples for conformance testing.

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5. At a minimum, the following conformance tests shall be performed.

Test	Procedure
Thickness	ASTM D5994
Density	ASTM D1505/ASTM D 792
Break Strength	ASTM D6693 Type IV
Break Elongation	ASTM D6693
Tear Resistance	ASTM D1004
Puncture Resistance	ASTM D4833
Carbon Black Content	ASTM D1603
Carbon Black Dispersion	ASTM D5596
Asperity Height	ASTM D7466

6. Prior to installation, the Engineer shall review the conformance test results against the material properties required by Table 1 of this Specification. Non-conforming material will be rejected and bracketed from subsequent rolls from the same product batch.

7. If geomembrane material is rejected due to failing conformance test results, the Contractor shall be responsible for all costs associate with additional material testing and replacement of materials as necessary.

C. Interface Friction/Direct Shear Testing

1. Prior to installation, samples of delivered geomembrane shall be taken and shipped to the Owner's geosynthetics laboratory for interface friction/direct shear testing.

2. Samples shall be at least 3 feet long by the roll width and shall not include the first 3 feet of any roll.

3. Interface friction/direct shear testing shall be conducted on the following interfaces:

   a. 40 mil textured LLDPE geomembrane versus sand (gas venting layer material); and

   b. 40 mil textured LLDPE geomembrane versus geosynthetic drainage composite.

4. Soil samples of on-site materials shall be collected by the Engineer for interface friction/direct shear testing.

5. Interface friction/direct shear testing shall be the responsibility of the Owner.

6. The Engineer shall review the results of the interface friction/direct shear test.

    a. If the Engineer determines that the proposed geomembrane will provide adequate slope stability, and the geomembrane rolls meet all other specifications, the geomembrane rolls shall be accepted.

    b. If the Engineer determines that the proposed geomembrane will not provide adequate slope stability, the geomembrane rolls shall not be accepted.

        1) The Contractor shall be responsible for removing all unacceptable geomembrane rolls from the site and replacing them with acceptable material.

D. Procedures for Determining Geomembrane Roll Test Failures

1. For test results reported in both machine and cross direction, results from each direction shall be compared to the acceptable specifications to determine acceptance.

2. For test methods requiring multiple samples, the criteria in Table 1 of this Specification shall be met based on average results of multiple specimen tests.

3. The following procedures shall be used for interpreting results:

    a. If the test results meet the specification values provided in Table 1 of this Specification, then the roll, batch and entire shipment, if applicable, shall be accepted provided the requirements of Section 2.3(A) are met; and

    b. If the test results do not meet the specification values provided in Table 1 of this Specification, then the roll and batch shall be retested at the Contractor's expense using specimens from the original roll sample or from another sample collected by the Engineer. For retesting, two additional tests shall be performed.

        1) If both retest values meet the specification values, then the roll and batch shall be accepted.

2) If one additional test fails, then the roll and batch shall be rejected without further recourse.

a) At the Contractor's expense, the Engineer may obtain samples from other rolls within the batch. Based on the test results from these samples, the Engineer may chose to accept a portion of the batch while rejecting the remainder.

b) If retesting does not result in passing test results as defined above, or if there is any other non-conformity with the material Specifications, then the geomembrane rolls shall be removed from the site. Once removed from the site, these same rolls shall not be resubmitted for use.

c) The Contractor shall be responsible for removing all non-conforming geomembrane rolls from the site and replacing with acceptable material.

2.4 TRANSPORTATION

Transportation of the geomembrane shall be the responsibility of the Geomembrane Manufacturer. The Geomembrane Manufacturer shall be liable for all damages to the materials incurred prior to and during transportation to the site.

2.5 HANDLING AND STORAGE

A. Handling, storage, and care of the geomembrane prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damages to the materials incurred prior to final acceptance of the final cover system.

B. The Contractor shall be responsible for storage of the geomembrane at the site. During storage, the geomembrane shall be protected from excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. The geomembrane shall be stored in accordance with any additional requirements of the Geomembrane Manufacturer.

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PART 3. EXECUTION

3.1 EARTHWORK

A. Surface Preparation

1. The Geosynthetics Installer shall provide certification in writing that the surface on which the geomembrane will be installed is acceptable. The surface shall be free of stones, litter, organic matter, irregularities, protrusion, loose soil, and any abrupt changes in grade that could damage the geosynthetic. The certification of acceptance shall be given to the Engineer prior to commencement of geomembrane installation.

2. Special care shall be taken to maintain the prepared soil surface.

3. No geomembrane shall be placed onto an area which has been softened by precipitation or which has cracked due to desiccation. The soil surface shall be observed daily to evaluate the effects of desiccation cracking and/or softening on the integrity of the soil liner.

4. Any damage to the soil surface caused by installation activities shall be repaired at the Geosynthetics Installer's expense.

5. The Geosynthetics Installer shall be responsible for dewatering areas that have been accepted for geomembrane deployment, including anchor trenches.

B. Geosynthetics Anchor Trench

1. The anchor trench shall be excavated prior to geomembrane placement to the lines, grades, and configuration shown on the Construction Drawings.

2. No loose soil shall be allowed in the anchor trench beneath the geomembrane.

3. The anchor trench shall be backfilled and compacted after the geosynthetics have been installed in the trench. Care shall be taken when backfilling the trenches to prevent any damage to the geomembrane.

4. Corners where the geomembrane adjoins the trench shall be slightly rounded to avoid sharp bends in the geomembrane.

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3.2 GEOMEMBRANE DEPLOYMENT

A. Layout Drawings: The Geosynthetics Installer shall produce layout drawings prior to geomembrane deployment. These drawings shall indicate the geomembrane configuration, dimensions, details, locations of seams, etc. Field seams shall be differentiated from factory seams (if any) on the drawings. Field seams shall be oriented up or down slope and not across slope. The layout drawings must be approved by the Engineer prior to the installation of any geomembrane. The layout drawings, as modified and/or approved by the Engineer shall become part of the Project Documents.

B. Field Panel Identification

1. A geomembrane field panel is defined as follows:

   a. If the geomembrane is not fabricated into factory panels, a field panel is a roll or a portion of roll cut in the field.

   b. If the geomembrane is fabricated into factory panels, a field panel is a factory panel or a portion of factory panel cut in the field.

2. Each field panel must be given an identification code (number or letter-number). This identification code shall be agreed upon by the Engineer and Geosynthetics Installer. The field panel identification code shall be related, through a table or chart, to the original resin, and the constituent rolls and factory panels.

C. Field Panel Placement

1. Field panels shall be installed as approved or modified at the location and positions indicated in the layout drawings.

2. Field panels shall be placed one at a time, and each field panel shall be seamed to adjacent panels the same day that it is placed.

3. Geomembranes shall not be placed when the ambient temperature is below 32°F, unless otherwise authorized by the Engineer.

4. Geomembranes shall not be placed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of winds exceeding 20 miles per hour.

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5. The Geosynthetics Installer shall employ placement methods consistent with the following:

   a. No vehicular traffic shall be allowed on the geomembrane.

   b. Equipment used shall not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or other means.

   c. Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane.

   d. The method used to unroll the panels shall not scratch or crimp the geomembrane and shall not damage the supporting soil.

   e. The prepared surface underlying the geomembrane shall not be allowed to deteriorate after acceptance of the surface, and shall remain acceptable up to the time of geomembrane placement.

   f. The method used to place the panels shall minimize wrinkles (especially differential wrinkles between adjacent panels).

   g. Temporary loads and/or anchors (e.g., sand bags, tires) not likely to damage the geomembrane may be placed on the geomembrane to prevent uplift by wind (in high winds, continuous loading is recommended along panel edges to minimize the risk of wind flow under the panels).

6. Any field panel or portion thereof that becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material at no cost to the Owner. Less serious damage may be repaired at the Engineer's sole discretion and at no cost to the Owner. Damaged panels or portions of damaged panels that have been rejected shall be removed from the work area.

3.3 FIELD SEAMING

A. Seam Layout: In general, seams shall be oriented parallel to the line of maximum slope, i.e., oriented down, not across, the slope. In corners and at odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be made within 5 feet of any toe of the slope, except where approved by the Engineer. No seams shall be located in an area of potential stress concentration, as defined by the Owner.

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B. Personnel: All personnel performing seaming operations shall be qualified as indicated in Section 1.4(C)(3). No seaming shall be performed unless a "master seamer" is present.

C. Weather Conditions for Seaming

1. Seaming shall not be attempted at ambient temperatures below 32°F or above 104°F or when wind velocity exceeds 20 miles per hour. At ambient temperatures between 32°F and 50°F, seaming shall be allowed if the geomembrane is preheated either by the sun or a hot air device, and if there is no excessive cooling from wind. At ambient temperatures above 50°F, no preheating will be required. In all cases, the geomembrane shall be dry and protected from excessive wind.

2. If the Geosynthetics Installer wishes to use methods that may allow seaming at ambient temperatures below 32°F or above 104°F, he shall demonstrate that the seam so produced is equivalent to those produced under normally approved conditions, and that the overall quality of the geomembrane is not adversely affected. In addition, an addendum to the Contract between the Contractor and the Geosynthetics Installer shall be required. The addendum shall specifically state that the seaming procedure does not cause any physical or chemical modification to the geomembrane that will generate any short or long term damage to the geomembrane.

3. To minimize geomembrane contraction stresses, seaming should ideally be carried out in the morning and late evening when the geomembrane is relatively contracted and during the middle of the day if overcast conditions prevail. If the geomembrane must be seamed in the middle of a sunny day, the Geosynthetics Installer shall ensure that the panels to be seamed are at the same temperature and that there is sufficient slack in the geomembrane to prevent the generation of excessive stresses or trampolining when the geomembrane contracts as cooler temperatures prevail. The required amount of slack shall be determined by the Geosynthetics Installer and it should not be so much so as to cause significant wrinkling of the geomembrane. If trampolining of the geomembrane is observed, the Geosynthetics Installer will be required to make repairs so that the problem is eliminated.

4. Ambient temperatures shall be measured 6 inches above the geomembrane surface.

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D. Overlapping and Temporary Bonding

1. Geomembrane panels shall be overlapped a minimum of 3 inches for extrusion welding and 5 inches for fusion welding, but in any event, sufficient overlap shall be provided to allow peel tests to be performed on the seam.

2. The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane. The temperature of the air at the nozzle of spot welding apparatus shall be controlled such that the geomembrane is not damaged.

3. No solvent or adhesive shall be used unless the product has been approved in writing by the Owner. Samples of any proposed solvent or adhesive shall be submitted to the Engineer for testing and evaluation at the Geosynthetics Installer's expense.

E. Seam Preparation

1. Prior to seaming, the seam area shall be cleaned and made free of moisture, dust, dirt, debris of any kind, and foreign material.

2. If seam overlap grinding is required, the process shall be completed according to the Geomembrane Manufacturer's instructions within one hour of the seaming operation and in a manner that does not damage the geomembrane. The grind depth shall not exceed 10% of the geomembrane thickness. Grinding marks shall not appear beyond 0.25 inch of the extrudate after it is placed.

3. Seams shall be aligned with the fewest possible number of wrinkles and "fishmouths".

F. General Seaming Requirements

1. Seaming shall extend to the outside edge of panels to be placed in the anchor trench.

2. If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface, directly under the seam overlap to achieve proper support.

3. If seaming operations are carried out at night, adequate illumination shall be provided by the Geosynthetics Installer for performing seaming activities.

4. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed where possible; any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane that extends a minimum of 6 inches beyond the cut in all directions.

G. Seaming Process

1. Approved processes for field seaming are extrusion welding and fusion welding. Seaming equipment shall be operated in a manner that does not cause damage to the geomembrane. Only apparatus that the Engineer has specifically approved by make and model shall be used. Proposed alternate seaming processes shall be documented and submitted to the Engineer.

2. Extrusion Equipment and Procedures

   a. The Geosynthetics Installer shall maintain at least one spare operable extrusion seaming apparatus on-site at all times.

   b. Extrusion welding apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle.

   c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel. Whenever the extruder is stopped, the barrel shall be purged of all heat-degraded extrudate.

   d. The Geosynthetics Installer shall provide documentation regarding the extrudate to the Engineer and shall certify that the extrudate is compatible with the specifications, and consists of the same resins as the geomembrane.

   e. The electric generator used for power supply to the welding machines shall be placed outside the area to be lined or mounted on soft tires such that no damage occurs to the geomembrane. The electric generator shall be equipped with a grounding rod that is driven into the ground outside the lined area. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

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3. Fusion Equipment and Procedures

   a. The Geosynthetics Installer shall maintain at least one spare operable seaming apparatus on-site at all times.

   b. Fusion-welding apparatus shall be automated vehicular-mounted devices equipped with gauges that show the instantaneous temperatures and pressures of the machine.

   c. The edges of cross seams shall be abraded to a smooth incline (top and bottom) prior to welding.

   d. A movable protective layer may be used directly below each geomembrane overlap to be seamed to prevent the buildup of moisture between the sheets.

   e. The electric generator used for power supply to the welding machines shall be placed outside the area to be lined or mounted on soft tires such that no damage occurs to the geomembrane. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after use.

H. Trial Seams

1. Trial seams shall be made prior to production seaming by all seamers and by all equipment to be used during production seaming. The trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Such trial seams shall be made at the beginning of each seaming period and at least once each five hours for each seaming apparatus used that day. Also, each seamer shall make at least one trial seam each day. Trial seams shall be made under the same conditions as actual seams. The trial seam sample shall be at least 5 feet long by 1 foot wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as specified in Section 3.3(D) of this Specification.

2. Two adjoining specimens, each 1 inch wide, shall be cut from the trial seam sample by the Geosynthetics Installer. The specimens shall be tested in shear and peel, respectively, using a field tensiometer, and the specimen shall fail by film tear bond rather than in the seam. If a specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus or seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

3. The trial seams shall meet the required strength values shown in Table 2 of this Specification.

I. Nondestructive Seam Continuity Testing

1. The Geosynthetics Installer shall nondestructively test all field seams over their full length using a vacuum test, air pressure test (for double fusion seams only), or other approved method. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. The installer shall complete any required repairs in accordance with Section 3.3(K) of this Specification. The following procedures shall apply to locations where seams cannot be nondestructively tested:

   a. If the seam is accessible to testing equipment prior to final installation, the seam shall be nondestructively tested prior to final installation.

   b. If the seam cannot be tested prior to final installation, the seaming operations must be observed in their entirety by the Engineer for uniformity and completeness.

2. Vacuum Testing

   a. The equipment shall comprise the following:

      1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.

      2) A steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections.

      3) A rubber pressure/vacuum hose with fittings and connections.

      4) A bucket and applicator.

      5) A soapy solution.

b. The following procedures shall be followed:

1) Energize the vacuum pump and reduce the tank pressure to approximately 5 pounds per square inch (psi) gauge.

2) Wet a strip of geomembrane seam having an area larger than the vacuum box assembly with the soapy solution.

3) Place the box over the wetted area.

4) Close the bleed valve and open the vacuum valve.

5) Ensure that a leak tight seal is created.

6) Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than 10 seconds.

7) If no bubbles appear after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inches overlap, and repeat the process.

8) All areas where soap bubbles appear shall be marked with a marker that will not damage the geomembrane and repaired in accordance with Section 3.3(K) of this Specification.

3. Air Pressure Testing (For Double Fusion Seams Only)

a. The following procedures are applicable to those processes which produce a double seam with an enclosed space.

b. The equipment shall comprise the following:

1) An air pump (manual or motor driven), equipped with a pressure gauge, capable of generating and sustaining a pressure between 25 and 30 psi, mounted on a cushion to protect the geomembrane.

2) A rubber hose with fittings and connections.

3) A sharp hollow needle, or other approved pressure feed device.

c. The following procedures shall be followed:

1) Seal both ends of the seam to be tested.

2) Insert needle, or other approved pressure feed device, into the channel created by the fusion weld.

3) Insert a protective cushion between the air pump and the geomembrane.

4) Energize the air pump to a pressure between 25 and 30 psi, close valve, allow two minutes for pressure to stabilize, and sustain the pressure for not less than five minutes.

5) If loss of pressure exceeds 4 psi, or if the pressure does not stabilize, locate faulty area and repair in accordance with Section 3.3(K) of this Specification.

6) Cut opposite end to verify continuity of seam, remove needle, or other approved pressure feed device, and seal repair in accordance with Section 3.3(K) of this Specification.

J. Destructive Testing

1. Destructive seam tests shall be performed on samples collected from selected locations to evaluate seam strength and integrity. Destructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

2. The destructive seam tests shall meet the required strength values shown in Table 2 of this Specification.

3. Sampling

a. Destructive test samples shall be collected at a minimum frequency of one test location per day per seaming crew or seaming machine at least every 500 feet of seam length (not including repairs). Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The Engineer will be responsible for choosing the locations. The Geosynthetics Installer shall not be informed in advance of the

locations where the seam samples will be taken. The Owner and/or Engineer reserve the right to increase the sampling frequency.

b. Samples shall be cut by the Geosynthetics Installer at the locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. All holes in the geomembrane resulting from the destructive seam sampling shall be immediately repaired in accordance with the repair procedures described in Section 3.3(K) of this Specification. The continuity of the new seams in the repaired areas shall be tested according to Section 3.3(I) of this Specification.

c. Two strips, 1 inch wide and 12 inches long with the seam centered parallel to the width, shall be taken. The strips shall be spaced a clear distance of 42 inches apart. These samples shall be tested in the field in accordance with Section 3.3(J)(3) of this Specification. If these samples pass the field test, a laboratory sample shall be taken. The laboratory sample shall be at least 1 foot wide by 42 inches long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

1) One 1-foot long portion to the Geosynthetics Installer for field testing;

2) One 1.5-foot long portion to the Engineer for laboratory testing; and

3) One 1-foot long portion to the Engineer for archival storage.

4. Field Testing: The two 1-inch wide strips shall be tested in the field using the field by tensiometer for peel and shear respectively. If any field test sample fails to pass, then the procedures outlined in Section 3.3(K) of this Specification shall be followed.

5. Laboratory Testing: Samples shall be tested in the laboratory in accordance with the methodology of ASTM D6392. Perform peel testing for dual hot wedge fusion welds on the inside and outside tracks.

a. Each destructive seam sample shall be tested for the following:

1) Shear strength, expressed in pounds per inch (ppi), when tested in general accordance with ASTM D6392.

2) Peel strength, expressed in ppi, when tested in general accordance with ASTM D6392.

b. The testing laboratory shall report the following values, along with the mean and standard deviations where appropriate, for each sample tested in shear:

1) Maximum tension in pounds per square inch;

2) Elongation at break (up to a tested maximum of 100%); and

3) The locus of failure.

c. The testing laboratory shall report the following values, along with the mean and standard deviations where appropriate, for each sample tested in peel:

1) Maximum tension in pounds per square inch;

2) Seam separation (expressed as percent of original seam area); and

3) The locus of failure.

d. Retesting of seams, because of failure to meet any or all of the specifications, may be performed at the sole discretion of the Engineer.

6. Destructive Test Failure

a. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the Owner's laboratory, the Geosynthetics Installer's laboratory, or by a field tensiometer. The Geosynthetics Installer shall have two options, as described in b and c below.

b. The Geosynthetics Installer can reconstruct the seam (e.g., remove the old seam and reseam) between any two passed test locations.

c. The Geosynthetics Installer can trace the welding path to an intermediate location, a minimum of 10 feet from the location of the failed test (in each direction) and take a small sample for an additional field test at each location. If these additional samples pass the tests, then full laboratory samples shall be taken. If these laboratory samples pass the tests, then the seam shall be reconstructed between these locations. If either sample fails, then the

process shall be repeated to establish the zone in which the seam should be reconstructed. In any case, all acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases where the length of reconstructed seam exceeds 150 feet, a destructive sample taken from within the reconstructed zone must pass destructive testing. Whenever a sample fails, the Engineer may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift.

K. Defects and Repairs

1. All seams and non-seam areas of the geomembrane will be examined by the Engineer for evidence of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be swept or washed by the Geosynthetics Installer if surface contamination inhibits examination. The Geosynthetics Installer shall ensure that this examination of the geomembrane precedes any seaming of that section.

2. Each suspect location, both in seam and non-seam areas, shall be nondestructively tested using the methods described Section 3.3(I) of this Specification, as appropriate. Each location which fails nondestructive testing shall be marked by the Engineer and repaired by the Geosynthetics Installer. Work shall not proceed with any materials which will cover repaired locations until laboratory test results with passing values are available.

3. When seaming of a geomembrane is completed (or when seaming of a large area of a geomembrane is completed) and prior to placing overlying materials, the Engineer shall identify all excessive geomembrane wrinkles. The Geosynthetics Installer shall cut and reseam all wrinkles so identified. The seams thus produced shall be tested like any other seams.

4. Repair Procedures

   a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired by the Geosynthetics Installer. Several repair procedures are specified below. The final decision as to the appropriate repair procedure shall be agreed upon between the Engineer and the Geosynthetics Installer. The procedures available include:

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LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE

1) Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;

2) Abrading and reseaming, used to repair small sections of extruded seams;

3) Spot seaming, used to repair small tears, pinholes, or other minor, localized flaws;

4) Capping, used to repair long lengths of failed seams; and

5) Removing bad seam and replacing with a strip of new material seamed into place (used with long lengths of fusion seams).

b. In addition, the following shall be satisfied:

1) Surfaces of the geomembrane to be repaired shall be abraded no more than one hour prior to the repair;

2) All surfaces must be clean and dry at the time of repair;

3) All seaming equipment used in repair procedures must be approved by the Engineer;

4) The repair procedures, materials, and techniques shall be approved in advance for the specific repair by the Engineer and Geosynthetics Installer;

5) Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 inches; and

6) The geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

5. Each repair shall be numbered and logged and shall be nondestructively tested using the methods described in Section 3.3(l) of this Specification, as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests will require the repair to be redone and retested until a passing test result is achieved. At the discretion of the Engineer, destructive testing may be required on large caps.

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LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE

3.4 MATERIALS IN CONTACT WITH THE LINER

A. The Geosynthetics Installer shall take all necessary precautions to ensure that the geomembrane is not damaged during its installation or during the installation of other components of the final cover system or by other construction activities. Installation on rough surfaces shall be performed carefully. If approved by the Engineer, additional loosely placed geotextile sections may be used by the Geosynthetics Installer to protect the geomembrane.

B. No granular materials shall be placed directly on the geomembrane at any time. A geotextile cushion shall be installed between aggregate and any geomembrane.

C. Equipment shall not be driven directly on the geomembrane. Unless otherwise specified by the Engineer, all equipment operating on materials overlying the geomembrane shall comply with the following:

Allowable Equipment Ground Pressure (psi)	Thickness of Overlying Compacted Fill (feet)
<5	1.0
<15	1.5
<20	2.0
>20	3.0

D. In heavily trafficked areas such as access ramps, and in areas trafficked by rubber tire vehicles, the thickness of overlying compacted fill shall be at least 3 feet.

E. Installation of the geomembrane in sump areas, and connection of the geomembrane to appurtenances shall be made according to these Specifications and as shown on the Construction Drawings. Extreme care shall be taken while seaming around sumps and appurtenances (where applicable), since neither nondestructive nor destructive testing may be feasible in these areas. The Geosynthetics Installer shall ensure that the geomembrane has not been visibly damaged while making connections to sumps and appurtenances. Because of the difficulty of vacuum testing seams in the sump area, fusion seams should be made at all possible locations in the sump.

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LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE

3.5 GEOMEMBRANE ACCEPTANCE

A. The Geosynthetics Installer shall retain all ownership and responsibility for the geomembrane until accepted by the Engineer.

B. The geomembrane will not be accepted by the Engineer until all of the following conditions are met:

1. The installation is finished;

2. All documentation of installation is completed including the Engineer's final report;

3. Verification of the adequacy of all field seams and repairs, including associated testing, is complete; and

4. Written certification documents shall be provided by the Geosynthetics Installer. Also, record drawings, certified by the Geosynthetics Installer and signed and sealed by a Professional Surveyor, shall be provided.

3.6 PRODUCT PROTECTION

A. The Contractor shall use all means necessary to protect all prior work and all materials and completed work of other Sections.

B. In the event of damage, the Contractor shall immediately make all repairs and replacements necessary, to the approval of the Engineer and at no additional cost to the Owner.

Table 1 – LLDPE Textured Geomembrane Factory QC Certification and QA Conformance Testing Protocol

Item	Test Method	Requirement
Thickness	ASTM D5994	40 mil nominal 38 mil (minimum average) 36 mil (lowest individual for 8 out of 10 values) 34 mil (lowest individual for any of the 10 values)
Density	ASTM D1505/ ASTM D 792	0.939 g/ml (maximum)
2% Modulus	ASTM D 5323	2400 (maximum)
Break Strength[3]	ASTM D6693 Type IV	60 lb/in (minimum average)
Break Elongation[4]	ASTM D6693	250% (minimum average)

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LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE

Item	Test Method	Requirement
Tear Resistance	ASTM D1004	22 lbs (minimum average)
Puncture Resistance	ASTM D4833	44 lbs (minimum average)
Carbon Black Content	ASTM D1603[5]	2.0% to 3.0%
Carbon Black Dispersion	ASTM D5596	9 in Categories 1 or 2 and 1 in Category 3
Axi-Symmetric Break Resistance Strain	ASTM D5617	30% (minimum)
Asperity Height[2]	ASTM D7466	10 mil (minimum average)
Oxidative Induction Time (OIT)	ASTM D3895 ASTM D5885	100 % (Standard OIT, minimum average) or[6] 400% (High Pressure OIT, minimum average)
Oven Aging at 85°C	ASTM D5721 ASTM D3895 ASTM D5885	35 % (Standard OIT, minimum average, retained after 90 days) or[6] 60% (High Pressure OIT, minimum average, retained after 90 days)
UV Resistance	ASTM D5885	35% (High Pressure OIT, minimum average, retained after 1600 hours)[7]

Notes:

1. Minimum test values based on current manufacturers specifications, and may change based on future manufacturers guaranteed minimum test values.
   g/mil = grams per thousandth of an inch
   lbs = pounds
   lb/in = pounds per inch
   mil = thousandth of an inch
2. Of 10 readings, 8 out of 10 must be greater than or equal to 7 mils and the lowest individual reading must be greater than or equal to 5 mils.
3. Machine direction and cross direction average values should be on the basis of 5 test specimens in each direction.
4. Machine direction and cross direction average values should be on the basis of 5 test specimens in each direction. Break elongation is based on a gage length of 2.0 inches at 2.0 inches/minute.
5. Other methods such as ASTM D 4218 (muffle furnace) of microwave methods are acceptable if an appropriate correlation to ASTM D 1603 (tube furnace) can be established.
6. The manufacturer has the option to select either one of the OIT methods listed (i.e., Standard OIT or High Pressure OIT).
7. UV resistance testing is not necessary for Standard OIT testing. The condition of the test should be 20 hours UV cycle at 75 °C followed by 4 hours condensation at 60 °C. UV resistance is based on percent retained value regardless of the original High Pressure OIP value.

Table 2 – LLDPE Textured Geomembrane Seam Testing

Item	Test Method	Frequency	Requirement
Bonded Shear Strength	ASTM D6392	1/500 feet (maximum)[1]	60 lb/in (minimum)
Peel Strength	ASTM D6392	1/500 feet (maximum)[1]	Fusion - 50 lb/in (minimum) Extrusion - 44 lb/in (minimum)

Notes:

1. For fusion welded seams, frequency is based on welding device footage; for extrusion welded seams, frequency is based on operator footage.
2. Minimum test values based on current manufacturers specifications, and may change based on future manufacturers guaranteed minimum test values. List Locus of Break in laboratory test results.

END OF SECTION

Fill Materials

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FILL MATERIALS

PART 1. GENERAL

1.1 SCOPE OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation and installation equipment necessary to install all fill materials as specified in the Project Documents.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D422 Standard Test Method for Particle-Size Analysis of Soils

2. D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 foot-pounds per cubic foot [ft lbf/ft^3] or 600 kilonewton-meters per cubic meter [kN-m/m^3])

3. D2434 Standard Test Method for Permeability of Granular Soils (Constant Head)

4. D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

5. D5084 10 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

6. D5519 Standard Test Methods for Particle Size Analysis of Natural and Man-Made Riprap Materials

B. Michigan Department of Transportation (MDOT) 2003 Standard Specifications for Construction

C. Michigan Test Method (MTM) 109 – Sieve Analysis of Aggregates

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FILL MATERIALS

1.3 QUALITY ASSURANCE

A. Quality Assurance Program: The Contractor shall agree to participate in and conform to all items and requirements of the quality assurance program as outlined in this Specification, and in the Project Documents.

1.4 SUBMITTALS

A. The following items shall be submitted no later than 14 days prior to the start of construction to the Owner and the Owner's Representative.

1. The Contractor shall submit the following information in order to confirm the suitability of each fill source:

a. Name, location and quantity of each source and type of fill material;

b. Samples of each source and fill material to be analyzed as described in the Project Documents;

c. Laboratory test data in conformance with the requirements of Section 2.2 of this Specification for each source and type of fill material; and

d. Proposed equipment to place, grade and compact fill materials.

PART 2. PRODUCTS

2.1 FILL MATERIALS

A. General Fill

1. General fill shall be used for the soil protection layer and as necessary to backfill areas following excavation.

2. General fill placed within 6 inches (above or below) of the final cover geosynthetics shall be free of sharp angular stones and other deleterious materials, and shall have a maximum particle size of 3 inches.

3. General fill to be obtained from off-site sources and from on-site soils that are acceptable for re-use (e.g., those soils excavated adjacent to the sheetpile wall and along the eastern berm at the A-Site Landfill).

ATTACHMENT B

FILL MATERIALS

4. General fill placed used for the soil protection layer shall have a maximum in-place hydraulic conductivity of 1x10-3 centimeters per second (cm/s).

B. Gas Venting Sand

1. Gas venting sand shall be locally available, well-sorted sand, free from angular and elongated objects and deleterious materials, with a relatively small fraction of fines.

2. Gas venting sand material shall have a minimum in-place hydraulic conductivity (ASTM D2434) of $1x10^{-3}$ cm/s, with less than 5 percent by weight passing the No. 200 sieve.

C. Filter Stone

1. Material placed around the final cover collection piping shall be washed rounded stone, with a D_{min} of ¾ inches and a D_{max} of 1½ inches.

2. Filter stone shall be wrapped with non-woven geotextile as shown on the Construction Drawings.

D. Select Aggregate Fill

1. Select aggregate fill placed within the gas cutoff trench and adjacent to gas vents and the lateral gas collection pipes shall consist of 3/8-inch washed pea gravel. Pea gravel shall be free of clay, shale, and organic matter.

E. Habitat Stone

1. Habitat stone material shall be washed, rounded to sub-angular stone with a minimum D_{50} of 6 inches, and D_{min} of 3 inches and a D_{max} of 9 inches.

F. Crushed Stone

1. Crushed stone material shall be used for the final cover access road surface and consist of compacted dense grade crushed stone Class II aggregate (MDOT 2003 Standard Specification for Construction Section 902.08) or equal.

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FILL MATERIALS

G. Open Graded Stone

1. Open graded stone material shall be used for the construction entrances and consist of dense graded aggregate Class 21AA (MDOT 2003 Standard Specification for Construction Section 902.06) or equal.

2.2 GENERAL REQUIREMENTS

A. Each source and type of fill material shall be tested as described below:

Type of Fill	Test Method	Frequency of Testing
General Fill	Standard Test Method for Particle Size Analysis of Soils - ASTM D422	Once per 5,000 cy
General Fill (used for the soil protection layer)	10 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter – ASTM D5084	Once per 5,000 cy
Gas Venting Sand	Standard Test Method for Permeability of Granular Soils (Constant Head) – ASTM D2434	Once per 5,000 cy
	Standard Test Method for Particle-Size Analysis of Soils – D422	Once per 2,500 cy
Filter Stone	Sieve Analysis of Aggregates – MTM109	Once per 5,000 cy
Select Aggregate Fill	Sieve Analysis of Aggregates – MTM109	Once per 5,000 cy
Habitat Stone	Standard Test Methods for Particle Size Analysis of Natural and Man-Made Riprap Materials – ASTM D5519	Once per 5,000 cy
Crushed Stone	Sieve Analysis of Aggregates – MTM109	Once per 5,000 cy
Open Graded Stone	Sieve Analysis of Aggregates – MTM109	Once per 5,000 cy

2.3 EQUIPMENT

A. The Contactor shall only use equipment that has been approved by the Engineer for this work. The Contractor shall submit details of proposed equipment to the Engineer for review a minimum of 14 days in advance of the Contractor's intention to bring the equipment to the site.

B. The Contractor shall furnish, operate and maintain grading equipment as is necessary to produce uniform layers, sections and smoothness of grade for compaction and drainage.

C. The Contractor shall furnish, operate and maintain compaction equipment as is necessary to produce required in-place density and moisture content.

D. The Contractor shall furnish, operate and maintain water tank trucks, pressure distributors or other equipment designed to apply water the requisite quantities of water uniformly and in a controlled manner to variable surface widths and distances.

PART 3. EXECUTION

3.1 PREPARATION AND RESTORATION

A. Fill materials shall be inspected prior to placement and all roots, vegetation and other foreign debris shall be removed.

B. Prior to placing the gas venting layer, material that would protrude more than 1 inch into the gas venting layer shall be removed, regraded or resized. Fill materials placed within 6 inches (above or below) of the final cover geosynthetics shall be free of sharp angular stones and other deleterious materials, and shall have a maximum particle size of 3 inches.

C. Stones shall not be allowed to form clusters with voids.

D. Remove ice and snow from subgrade prior to placing any fill materials. Do not place fill materials on frozen, wet or soft subgrade.

E. Soft areas of unsuitable subgrade are to be replaced with suitable subgrade material.

F. Prior to placing fill materials, proof-roll subgrade using appropriately sized and type compaction equipment.

3.2 PLACEMENT AND COMPACTION

A. Vegetative Soil

1. The vegetative soil (Vegetative Soil, Seeding, and Mulch Specification) shall be applied in a single loose lift that once compacted (i.e., compaction that results from placement and grading) of not less than 6 inches in thickness.

2. No compaction is required or allowed other than that which occurs as a result of placement, tracking and grading.

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FILL MATERIALS

B. General Fill

1. In areas directly over the geosynthetics, place, grade and compact general fill using an initial minimum lift thickness of 15 inches (compacted thickness and a second lift thickness of a minimum of 9 inches (compacted thickness). In other areas, place, grade and compact general fill in uniform lift thicknesses to achieve the specified compaction requirements. Completed lift thicknesses following compaction shall not exceed 12 inches, with the exception of the initial lift placed over geosynthetics.

2. Maintain proper moisture content to achieve specified compaction requirements.

3. No compaction is required for general fill material placed over the final cover geosynethtics other than that which occurs as a result of placement and grading.

4. General fill placed in areas other than over the final cover geosynthetics shall be compacted as required during construction based on encountered conditions. General fill may need to be compacted to 95 percent of the maximum standard proctor dry density as determined according to ASTM D698 or by multiple passes of suitably sized equipment.

5. General fill placed over the final cover geosynthetics shall be worked into place from the toe of slope upward to the top of slope to the greatest extent practicable, not exceeding more than 45 degrees from the flowline slope to avoid strain on the geosynthetics material.

C. Gas Venting Sand

1. Place, grade and compact gas venting sand in uniform lift thicknesses to achieve the specified compaction requirements. Completed lift thicknesses following compaction shall not exceed 12 inches.

2. No compaction is required for gas venting sand other than that which occurs as a result of placement and grading.

D. Filter Stone

1. Filter stone shall be placed such that it results in a compacted minimum thickness of 6 inches as shown on the Construction Drawings.

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FILL MATERIALS

2. No compaction is required for filter stone material other than that which occurs as a result of placement and grading.

E. Select Aggregate Fill

1. Place and spread select aggregate fill in lift thicknesses as required to obtain the specified compaction requirements. Maximum lift thicknesses of 12 inches after compaction shall not be exceeded.

2. No compaction is required for select aggregate fill material other than that which occurs as a result of placement and grading.

F. Crushed Stone

1. Access road material shall be placed such that it results in a compacted minimum thickness of 8 inches as shown on the Construction Drawings.

2. Access road material shall be compacted to 95 percent of the maximum standard proctor dry density as determined according to ASTM D698.

G. Open Graded Stone

1. Open graded stone material shall be placed as shown on the Construction Drawings and graded with suitably sized equipment. No specific compaction is required.

H. General Requirements

1. In general, fill material shall be placed and compacted in horizontal layers no less than 3 inches and not exceeding the thicknesses indicated on the Construction Drawings. The subgrade for placement of fill material shall be approved by the Engineer. Fill material shall not be placed on ground that shall not support the weight of construction equipment.

2. Each layer of soil fill material shall be thoroughly tamped or rolled to the required degree of compaction by mechanical tampers, or vibrators. Successive layers shall not be placed until the layer under construction has been thoroughly compacted.

ATTACHMENT B

FILL MATERIALS

3. The Contractor shall employ placement and compaction methods that do not disturb or damage piping or geosynthetics.

4. The Contractor will avoid equipment operations (e.g., sudden start-stops, tight turning-pivoting, inadequate protective cover thicknesses) that could result in damage to underlying materials (i.e., completed placement of soils/aggregates, piping, geosynthetics, etc).

5. Any observed equipment operations that, in the opinion of the Engineer, could lead to damage of underlying materials, will be investigated by the Engineer. Underlying materials that are identified as being damaged due to questionable equipment operations will be replaced in full accordance with the Project Documents at no additional cost to the owner (including those associated project schedule delays).

6. The Contractor shall not use heavy compaction equipment (i.e., greater than 5 pounds per square inch [psi] ground pressure) over piping or geosynthetics that area covered by less than 15 inches of fill material.

7. Trucks or other heavy equipment shall not be operated over any fill layer until the minimum thickness of soil fill has been placed and properly compacted by tampers or other approved method.

8. The Contractor shall begin placing fill materials at the lowest elevation of the area to be backfilled.

9. Drainage of the areas being backfilled shall be maintained at all times.

10. Where required, the Contractor shall add water to the fill materials in order to meet compaction requirements at no additional expense to the Owner. If, due to rain or other causes, the material is too wet for satisfactory compaction, the fill materials shall be allowed to dry or be removed as required, prior to compaction.

11. At the end of a day, the Contractor shall track the slope with a bulldozer perpendicular to the slope to help minimize erosion.

ATTACHMENT B

FILL MATERIALS

3.3 FIELD TESTING AND QUALITY CONTROL

A. In-place density tests (using ASTM D6938) shall be performed by an independent testing laboratory at the Contractor's expense. Tests will be required at a minimum of one test per each lift of backfill placed or at a frequency of 1 passing test per 5,000 square feet of subgrade, 100 cubic yards of soil fill, or 100 linear feet of pipe bedding, whichever results in the greatest frequency.

B. The Engineer may request additional in-place density tests to ascertain conformance with the compaction requirements presented in Section 3.2 of this Specification.

C. Material thicknesses may be confirmed by as-built survey or the Engineer may approve material thickness by hand-shoveling and measuring the observed material thickness.

3.4 CRITERIA AND TOLERANCES

A. Fill materials shall be constructed to such heights as to allow for post-construction settlement. Any settlements that occur before final acceptance of the Contract shall be corrected to make the backfill conform to the lines and grades shown on the Construction Drawings.

B. The thickness of the fill materials shall be ± 0.1 foot from the thickness indicated on the Construction Drawings.

END OF SECTION

Restoration Plantings

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ATTACHMENT B

RESTORATION PLANTINGS

PART 1. GENERAL

1.1 SCOPE OF WORK

A. The Installer shall furnish all labor, materials, tools, supervision, transportation and installation equipment necessary for the installation and establishment of vegetation as specified in the Project Documents. The Installer shall be under direct contract to the Contractor.

B. The Work includes the application of seeds and planting of trees and shrubs within the restoration areas: Riparian Corridor, Emergent Wetland, Forested Wetland, Forested Upland, and Tree Screen

C. The Contractor shall perform all post-construction activities necessary for the establishment of vegetative growth as specified herein on all seeded and planted areas until final acceptance is given by the Owner as described in Section 3.10 of this Specification.

1.2 REFERENCES

A. United States Clean Water Act Section 404

B. Section Part 301, Inland Lakes and Streams, of the Michigan Natural Resources and Environmental Protection Act (NREPA)

C. Part 91, Soil Erosion and Sedimentation Control, of NREPA

D. Part 303, Wetlands Protection, of NREPA

E. Rivers and Harbors Act

F. Fill Materials Specification

G. Vegetative Soil, Seeding, and Mulch Specification

1.3 QUALITY ASSURANCE

A. Quality Assurance Program: The Contractor shall agree to participate in and conform to all items and requirements of the quality assurance program as outlined in this Specification, and in the Project Documents.

ATTACHMENT B

RESTORATION PLANTINGS

1.4 QUALIFICATIONS

A. Contractor:

1. The Vegetation Installer shall meet the qualification requirements of this Specification.

B. Vegetation Installer:

1. Company specializing in work of this section with a minimum of 5 years of experience in planting and establishing wetland and upland plant communities with documented references. Personnel used to perform the installation of plant materials shall also have occupational experience in vegetation restoration projects.

2. Obtain seed stock only from established Vendors capable of providing seed quantities adequate to complete this project. Seed Vendors will be required to provide the data requested under Section 1.5(A) of this Specification prior to use of that seed.

3. Obtain planting stock only from established Vendors capable of providing plant stocks in quantities and at quality levels adequate to complete the project. Plant Vendors will be required to provide the data requested under Section 1.5(B) of this Specification prior to use of that stock.

1.5 SUBMITTALS

A. Certificates: submit certificates from seed vendors for each seed mixture or type of seed required. The certificates shall include the following: the botanical name and common name, percentage of seeds by weight in a mixture, purity of the seed, germination percentage, the amount of undesirable plant seeds present in the mixture, date of production, date of packaging and name and address of Vendor(s). Submit at least 4 weeks prior to time of planting to the Owner and the Owner's Representative.

B. Certificates: submit certificates from plant stock vendor for each group of plant stock required, stating botanical name, common name, origin, age, date of packaging, and name and address of vendor. Submit at least 4 weeks prior to planting to the Owner and the Owner's Representative.

C. Maintenance data: include maintenance instructions, application frequency and dosage of fertilizer, if necessary. Methods to control undesirable plant species and grazing by herbivores, such as Canada goose, white-tailed deer, beaver, and muskrat, shall be included in this submittal.

PART 2. PRODUCTS

2.1 POTENTIAL VENDOR

A. Seed, Shrub, and Tree Stock

JF New
PO Box 100
Holt, Michigan 48842
517.898.9018

B. Alternate vendors may be considered. The Contractor shall submit requests to the Owner for approval.

2.2 VEGETATIVE SOIL, FERTILIZER, AND MULCH

A. Vegetative soil, fertilizer, and mulch shall be in accordance with the Vegetative Soil, Seeding, and Mulch Specification.

2.3 SEED MIXTURES

A. Seed mixtures for restoration areas shall contain species and quantities (by weight) as specified on Construction Drawing 9.

B. Seed mixtures shall be blended by the vendor. The ratios of the various species specified on Construction Drawing 9 shall be guaranteed by the vendor.

C. Seed mixtures will be delivered in original sealed containers. Label containers with the following information:

1. Analysis of seed mixture;

2. Percentage of pure seed;

3. Year of production;

4. Net weight;

5. Date when tagged and location; and

6. Name and address of vendor.

D. Seeds in damaged packaging are not acceptable. Seeds shall be stored in weatherproof and rodent-proof enclosures.

E. All seeds shall have the proper stratification and/or scarification to break seed dormancy for other than fall planting.

F. Alternate seed mixes establishing equivalent ecological communities may be considered. The Contractor shall submit the alternate material to the Engineer for review.

2.4 TREE AND SHRUB STOCK

A. Tree and shrub types, height, planting density and spacing for each species shall be as specified on the Construction Drawing 9.

B. Plants shall be free of insects and diseases and shall show the appearance of healthy growth and vigor. Root stocks shall display evidence of new growth prior to planting.

C. All plant materials shall comply with state and federal laws with respect to inspection for plant diseases and insect infestations.

D. Each species shall be handled and placed in a manner that is consistent with good trade practice to ensure that plants arrive at the site in good condition. Plants that arrive dried out, exposed to excessive heat or that have been in storage for extended periods of time will not be accepted. If, upon inspection, the plants or root stocks display mold or decay, the material will not be accepted.

E. All containerized trees and shrubs shall be at least 40 inches and 24 inches, respectively, in aboveground height container stock and have a heavy fibrous root system that has been developed by proper horticultural treatment, transplanting and root pruning.

F. Live stakes will be dormant stem cuttings of 1/2 to 2 inches in diameter and at least 36 inches in length. Cuttings will have clean angled cuts at the bottom and flat cuts at the top, without split ends, and will have at least two live lateral buds on the portion of the stake that will be above-ground. Trim any lateral branches.

G. All plant stock that is to be placed in saturated or flooded soil conditions shall be pre-conditioned for this placement by being held in a wet environment at the nursery prior to shipment to the site.

H. All plant stock shall be stored in aboveground locations in non-construction areas approved by the Engineer. All plant stock shall have soil placed about roots sufficient to protect from desiccation and to provide nourishment during storage. All plants stored in the field prior to installation shall be kept cool and shall be sheltered from the drying effects of direct sunlight and prevailing winds. Plants should not be subject to freezing, drying or warming. It is the Contractor's responsibility to supply adequate water for all plant stock to maintain it in a healthy and vigorous state suitable for transplanting.

2.5 TRANSPORTATION

A. Transportation of the vegetative material shall be the responsibility of the Vendor. The Vendor shall be liable for all damages to the materials incurred prior to and during transportation to the site.

2.6 HANDLING AND STORAGE

A. Handling, storage, and care of the vegetative materials prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damages to the materials incurred prior to final acceptance of the restored areas.

PART 3. EXECUTION

3.1 VEGETATIVE SOIL PLACEMENT

A. Vegetative soil material shall be placed as described in the Vegetative Soil, Seeding, and Mulch Specification.

ATTACHMENT B

RESTORATION PLANTINGS

3.2 FERTILIZER APPLICATION

A. Apply fertilizer to prepared riparian corridor and forested upland surfaces uniformly at the rate of 20 pounds per 1,000 square feet. Fertilizer shall not be applied to restored wetland areas.

3.3 SEEDING AND PLANTING

A. Pre-Planting

1. Seedbed Preparation: Shallow disc and subsequently rake the seedbed of the areas to be seeded to provide a uniform and firm seedbed, free of all live plant materials, including perennial rhizomes. If the soil is saturated, tilling may not be necessary.

2. Fertilizer Application: Apply fertilizer at the prescribed rate.

3. Site Evaluation: The Contractor and the Vegetation Installer shall inspect the proposed sites with the Engineer at least one week prior to the onset of field planting activities to review the condition of the site. The site condition is defined as an evaluation of soils, water levels and grades of the site in terms of conditions that are appropriate for introduction of plantings. Do not proceed with the planting program in any area until all necessary modifications and/or corrections are completed and approved by the Engineer. If other conditions that are detrimental to installation or plant growth or to the safety of the planting crew are encountered, immediately notify the Engineer prior to performing planting activities.

B. Seeding

1. Use seed stocks and seeding rates consistent with Construction Drawing 9. Ecologically equivalent seed mixes can be used if approved in advance by the Engineer.

2. Perform seeding within the time guidelines specified in Section 3.7 of this Specification.

3. Seed the entire restoration areas using broadcast seeding methods. Lightly rake broadcast areas within 12 hours to ensure proper soil-seed contact.

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4. Where saturated soils make the use of mechanical seeding equipment impractical, hydroseeding techniques may be used with the prior approval of the Engineer.

5. Reseed areas with gaps in the areas of seeding in excess of 8 square feet.

6. Install temporary erosion control fabric over the seeded areas within the Riparian Corridor, as shown on the Construction Drawings.

7. Install straw mulch over all seeded areas that are not covered by erosion control fabric as described in the Vegetative Soil, Seeding, and Mulch Specification.

8. Mark seeded areas to prevent intrusion by foot traffic and/or equipment.

9. Perform an initial watering of seeded areas at a rate of 25,000 gallons per acre, and repeat after the second and fourth weeks following seeding if natural rainfall is less than 1 inch per week. The Contractor shall avoid creating rills and furrows as a result of watering and must repair and reseed any rills and furrows resulting from over watering.

10. Hydroseeding may be accepted as an alternative method of applying fertilizer, seed, and mulch. The Contractor shall submit the Installer's experience with using hydroseeding applications specific to wetland areas and relevant data regarding materials and application rates to the Engineer for review.

C. Live Stake Plantings

1. Use species, plant sizes and numbers presented in Construction Drawing 9.

2. Prior to placement of the live stakes, install temporary erosion control fabric on the prepared surface.

3. The lengths of live stakes depend upon the application. If through soil-choked stone, the length shall extend through the surface of the stone fill. At least half the length shall be inserted into the soil, below the stone fill.

4. Live stakes shall be cut to a point on the basal end for insertion into the ground.

5. A dibble, iron bar, or similar tool shall be used to make a pilot hole to prevent damaging the material during installation.

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6. Use a dead blow hammer to drive stakes into the ground.

7. Live cuttings shall be inserted by hand into pilot holes. Minimum 2 to 4 inches and two live buds of the live stake shall be exposed above the prepared surface. When possible, tamp soil around live stakes.

8. Care shall be taken not to damage the live stakes during installation. The stake must not be split and the bark must not be excessively damaged during installation. Damaged stakes shall be trimmed back to undamaged condition or replaced in-kind.

D. Containerized Tree and Shrub Plantings

1. Use species, plant sizes and numbers presented in Construction Drawing 9.

2. Dig holes at least 2 times the diameter and 0.5 times the depth of the plant root system to be installed at that location.

3. Remove non-biodegradable containers prior to planting.

4. Plant tree and shrub stocks by hand unless mechanical means are acceptable to the Engineer.

5. Set plants into their final locations following recommended horticultural practice for that species, taking specific note to plant species in appropriate habitats, as presented in Construction Drawing 9.

6. Plant tree species in a random spacing and in the habitat types indicated on Project Construction 9, Table 4 to establish vegetative communities. Support planted trees with two stakes and two ties looped around the trunk (not wrapped or tied).

7. Plant same shrub and live stake species in groupings of three to five individuals and in the habitats indicated on Construction Drawing 9, Table 4 to establish vegetative communities.

8. Protect trees, shrubs and live stakes from beaver, whitetail deer and muskrat herbivory with fencing, wraps or chemical deterrents. Herbivore control methods must be approved by the Owner prior to implementation.

9. Install wood chip mulch by hand around trees and shrubs to form a continuous blanket over the soil surrounding the plant, approximately 2 inches uniform thickness at loose measurement.

10. Perform an initial watering of planted areas at a rate of 25,000 gallons per acre, and repeat after the second and fourth weeks following seeding if natural rainfall is less than 1 inch per week. The Contractor shall avoid creating rills and furrows as a result of watering and must repair and reseed any rills and furrows resulting from over watering.

3.4 TEMPORARY EROSION CONTROL MAT

A. Biodegradable erosion control mat shall be installed within the riparian corridor along Willow Blvd and A-Site landfills, as shown on the Construction Drawings.

B. Biodegradable erosion control mat shall be installed in accordance with manufacturer's instructions.

3.5 MULCH

A. Straw mulch shall be installed within all restoration areas, with the exception of open water habitat and those areas covered by biodegradable erosion control blanket.

B. Restored areas not receiving temporary erosion control fabric will be covered with straw mulch. Mulch will be hand or machine spread uniformly at a rate of 1.5 to 2 tons per acre to form a continuous blanket over the seed bed, with no greater than 2 inches in uniform thickness at loose measurement with a minimum of 90 percent surface coverage. Excessive amounts or bunching of mulch shall not be permitted. Unless otherwise specified, mulch shall be left in place and allowed to decompose.

3.6 ENVIRONMENTAL REQUIREMENTS OF SEEDING AND PLANTING

A. Do not apply seed slurry when wind conditions are such that materials may be carried beyond designated areas, or that materials may not be uniformly applied, or when wind velocity exceeds 5 miles per hour.

B. Seeding activities shall not be carried out on days with heavy precipitation that will result in washing the plantings into the body of water where they will not survive.

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C. Do not install plant life when the temperature may drop below 35 degrees Fahrenheit (°F) or rise above 90 °F.

D. Do not install plant life when the wind velocity exceeds 30 miles per hour.

3.7 SEQUENCING AND SCHEDULING

A. Vegetative soil placement shall be scheduled to allow seeding and planting operations to be completed under optimum growing conditions during normal planting seasons. Do not compact vegetative soil prior to seeding and/or planting.

B. Seeding and planting operations shall be performed between April 1 (or as soon thereafter as the soil can be worked) and July 30. Seeding and planting may also be done from October 1 to freeze-up. Seeding and planting is not recommended between August 1 and October 1 without supplemental watering.

3.8 PRODUCT PROTECTION

A. Mark seeded and planted areas to prevent intrusion by foot traffic and/or equipment. Institute measures to protect completed landscape areas.

B. The Contractor shall use all means necessary to protect all prior work and all materials and completed work of other Sections.

C. In the event of damage, the Contractor shall immediately make all repairs and replacements necessary to the satisfaction of the Engineer and at no additional cost to the Owner.

3.9 MAINTENANCE OF RESTORED AREAS

A. Contractor is responsible for maintenance responsibilities beginning immediately after planting and continuing through one full growing season following the year of completion of planting. Required maintenance activities for the first year will be identified based on the results of monitoring activities performed by the Contractor during the first growing season following planting. Maintenance activities will be performed by the Contractor if any of the following performance standards are not met.

B. All planted trees and shrubs are required to be covered under warranty for one year from the date of installation. Any tree or shrub that dies within the warranty period

shall be replaced with the same plant species and size originally installed, unless otherwise instructed by the Engineer. Replanting will be performed at no additional cost to the Owner.

C. Maintenance responsibilities include the control of undesirable plant (e.g., invasive or exotic) species. Maintenance activities for undesirable plant control include mowing, physical removal and restricted hand application use of herbicides. Herbicide use shall be performed subject to the appropriate limitations of local and state regulation, including material safety data sheet review and approval of any chemicals brought on site prior to use. Maintenance of wetlands as well as all associated buffers or other habitats should address response to the species listed in Table 1 below and any other species identified as a problem at the site.

Table 1 – Undesirable Species

Scientific Name	Common Name
Phragmites australis	Common reed
Lythrum salicaria	Purple loosestrife
Rhamnus spp.	Buckthorns
Elaeagnus spp.	Olives
Rosa multiflora	Multiflora rose
Phalaris arundinacea	Reed canary-grass
Polygonum cuspidatum	Japanese knotweed

D. Maintenance responsibilities include control of herbivores and other vectors that threaten the establishment of a vegetative community; acts of vandalism resulting in damage; acts of nature that result in erosions, fires, wind damage, ice storms and similar situations. The Contractor shall take necessary action to correct and restore the system.

E. At a minimum, schedule maintenance activities to support seeding and planting under optimum growing conditions during normal planting seasons, as specified above.

F. Notify the Engineer and/or Owner prior to and following any maintenance activity.

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3.10 CRITERIA FOR ACCEPTANCE

A. The installed thickness of the vegetative soil layer will be assessed in accordance with the Vegetative Soil, Seeding, and Mulch Specification.

B. Vegetation will be evaluated one year following the date (as agreed upon by the Owner and Contractor) of completed construction work to determine if the vegetative growth established during this period is acceptable. The Owner and Engineer will meet with the Contractor following completion of the monitoring activities and review the restoration areas completed with a vegetative cover.

C. All seeded areas are required to exhibit 80 percent ground cover by desirable species by the end of the first growing season. Areas or portions of areas greater than 50 square feet that do not exhibit 80 percent or greater ground cover must be reseeded at no additional cost to the Owner. Reseed or replant to maintain a minimum of 80 percent cover by non-invasive hydrophytes in emergent wetlands. Reseed or replant to maintain a minimum of 60 percent cover by non-invasive hydrophytes of which at least 15 percent are woody species in forested cover types.

END OF SECTION

Vegetative Soil, Seeding, and Mulch

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ATTACHMENT B

VEGETATIVE SOIL, SEEDING, AND MULCH

PART 1. GENERAL

1.1 SCOPE OF WORK

A. Work under this section consists of furnishing and placing of vegetative soil, fertilizer, seed, and mulch as specified in the Project Documents.

B. The Contractor shall perform all post-construction activities necessary for the establishment of vegetative growth as specified herein on all seeded areas until final acceptance is given by the Owner as described in Section 3.3 of this Specification.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D4972 Standard Test Method for pH of Soils; and

2. D2974 Standard Test Methods for Moisture, Ash and Organic Matter of Peat and other Organic Soils.

1.3 QUALITY ASSURANCE

A. Quality Assurance Program: The Contractor shall agree to participate in and conform to all items and requirements of the quality assurance program as outlined in this Specification, and in the Project Documents.

1.4 SUBMITTALS

A. Analysis of the seed [to demonstrate compliance with the seed mix specified in Section 2.1(D) of this Specification] and fertilizer (to identify chemical composition), and proposed application rates [to demonstrate compliance with the fertilizer application rate identified in Section 3.1(B) of this Specification] shall be submitted to the Owner and the Owner's Representative.

B. Should hydroseed be used, the Contractor shall submit all data including material and application rates and methods to the Owner and the Owner's Representative.

C. Sample of proposed vegetative soil to be tested by the contractor for the chemical contaminants specified in the Project Documents.

D. Analysis of the vegetative soil for organic content and pH.

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VEGETATIVE SOIL, SEEDING, AND MULCH

PART 2. PRODUCTS

2.1 MATERIALS

A. Any off-site vegetative soil shall be unfrozen, friable, natural material and shall be free of clay lumps, brush needs, litter, stumps, stones, and other extraneous matter. The vegetative soil shall have an organic content between 5 and 20 percent (ASTM D2974), and a pH between 5.5 and 7.5 (ASTM D4972).

B. Fertilizer shall be a standard quality commercial carrier of available plant food elements. Fertilizer specifications will be outlined after nutrient testing of the topsoil is completed to determine the actual nutrients needs and avoid discharge of excess fertilizer components into the surface water bodies. The Contractor shall determine the appropriate fertilizer following adequate testing of vegetative soil samples and submit the proposed fertilizer material to the Engineer for approval.

1. Each bag of fertilizer shall bear the Manufacturer's guaranteed statement of analysis.

C. Seed mixtures shall be of commercial stock of the current season's crop and shall be delivered in unopened containers bearing the guaranteed analysis of the mix. All seed shall meet the State standards of germination and purity.

D. Seed mix to be used in vegetated areas other than those subject to restoration as described in the Restoration Plantings Specification shall be: 65 percent Kentucky Blue Grass, 20 percent Perennial Rye Grass, and 15 percent Fescue. The seed mixture will be seeded at a rate of 150 pounds per acre.

E. Mulch shall be stalks of oats, wheat, rye, or other approved materials free from noxious weeds and coarse materials.

PART 3. EXECUTION

3.1 INSTALLATION

A. The vegetative soil shall be applied in a single loose lift of not less than 3 inches and shall have a final thickness as shown on the Project Documents. No compaction is required or allowed. Following placement of vegetative soil and prior to fertilizer application, all stones greater than 1-inch in diameter, sticks, and other deleterious material shall be removed.

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B. The fertilizer shall be applied to the surface uniformly at a rate that is determined by the Contractor and approved by the Engineer in accordance with Section 2.1(B). After the vegetative soil surface has been fine graded, the seed mixture shall be uniformly applied upon the prepared surface with a hydroseeder at the specified rate, unless otherwise recommended by the seed manufacturer and accepted by the Engineer.

C. Hydroseeding shall include application of fertilizer, seed, mulch, and tackifier. The Contractor must submit all data regarding hydroseed materials, equipment and application rates to the Engineer for review and acceptance.

D. Mechanical spreading of seed may be considered as an alternative to hydroseeding for select areas. The method for mechanical seed application shall include the following.

1. The seed shall be raked lightly into the surface.

2. Seeding and mulching shall not be done during windy weather.

E. The mulch shall be hand or machine spread to form a continuous blanket over the seed bed, at a rate of 1.5 to 2 tons per acre with no more than 2 inches in uniform thickness at loose measurement. Excessive amounts or bunching of mulch shall not be permitted.

1. Unless otherwise specified, mulch shall be left in place and allowed to decompose.

2. Any mulch that has not disintegrated at time of first mowing shall be removed.

3. The mulch shall be placed with a tackifier.

F. Seeded areas shall be watered as often as required to obtain germination, and to obtain and maintain a satisfactory sod growth. Watering shall be performed in such a manner as to prevent washing out of seed and mulch.

3.2 MAINTENANCE

A. All erosion rills or gullies within the vegetative soil layer shall be filled with additional approved vegetative soil, graded smooth, and re-seeded and mulched in accordance with this section.

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VEGETATIVE SOIL, SEEDING, AND MULCH

B. The contractor shall also be responsible for repairs to all erosion of the seeded areas until all new grass is firmly established and reaches a height of not less than 4 inches. All bare or poorly vegetated areas must be re-seeded and mulched in accordance with this Specification.

C. The contractor shall water any vegetation if necessary to achieve acceptable vegetative growth, as defined in Section 3.3, during the one year period following the date (as agreed upon by the Owner and Contractor) of completed construction.

3.3 CRITERIA FOR ACCEPTANCE

A. Vegetative Soil Thickness

1. The installed thickness of the vegetative soil layer will be assessed using available survey data and may be required by the Engineer to be confirmed by test holes dug at random intervals throughout the soil cover area. The test holes will be dug by shoving of the vegetative soil to the top of the general soil fill layer. The thickness of the vegetative soil layer will determined by measuring the depth of the test hole [i.e., from the top of the vegetative soil layer to the top of the soil protection (general fill) layer]. The acceptable thickness will range from a 6 to 7 inches. The Contractor shall place additional vegetative soil over areas determined to have insufficient thickness. Areas of excessive thickness (i.e., greater than 7 inches) will be reviewed by the Owner, Engineer and the Contractor to determine if the excess soil quantity should be regarded elsewhere on-site or left in-place at no additional cost to the Owner in either case.

B. Vegetative Growth

1. Vegetation will be evaluated one year following the date (as agreed upon by the Owner and Contractor) of completed construction work to determine if the growth established during this period is acceptable. The Owner and Engineer will meet with the Contractor prior to the end of the one year period and review the project areas completed with vegetative cover. Acceptable growth will be determined based on visual assessment of the vegetated areas. Criteria consider during this assessment will include evidence of stressed vegetation, areas lacking in vegetation, clumped growth and average stem density. In general, stem density will be considered acceptable if the density is viewed as being 80 percent or greater.

END OF SECTION